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Abstracts for Winning Proposals

Proposal Number	ACT-02-0055
Title	Electro-Optic Imaging Fourier Transform Spectrometer
PI	Chao, Tien-Hsin
Abstract	
The overall objective of the proposed effort is to develop and demonstrate an innovative compact (spectrometer optical head 25 mm x 150 mm cylinder), low mass (< 2kg), Electro-Optic Imaging Fourier Transform Spectrometer (E-O IFTS) with no moving parts. This E-O IFTS would utilize an innovative electro-optic time delay mechanism for spectroscopic data collection to enable the development of very compact (one to two orders of magnitude reduction) IFTS instrument with much higher reliability in a space environment. The design goal of the E-O IFTS would be: spectral region 3.5 □ 6.5 mm (2850 □ 1540 cm-1), spectral resolution .25 cm-1, Speed < 0.5 sec per spectral measurement. This spectrometer would be tailored for the measurement of a large number of different atmospheric gases simultaneously in the same airmass. The low mass, low volume and high-reliability characteristics of the E-O IFTS will make it particularly suitable for integrating into Earth orbiting satellites for long-duration monitoring of atmospheric trace gases, CO2 Column Abundance and Profile, and Topography and Surface Change as requested to solve challenges in the Atmospheric Chemistry, Global Carbon Cycle, and Solid Earth Science areas of the NASA Earth Science Program. This E-O IFTS consists of an imaging optics, a series of cascaded birefringent elements sandwiched between a series of liquid crystal based electro-optic switches, and a broadband IR photodetector array. New Liquid Crystal (LC) and IR birefringent polymer materials would be used to develop a high-transmission, low-noise E-O IFTS operated in the infrared spectral band. An E-O IFTS breadboard will be integrated and tested for Fourier spectroscopy measurements of a variety of atmospheric gases in the laboratory. Successful development of this E-O IFTS will place it at TRL4. It would be a candidate for further integration into the NASA Instrument Incubator Program for full-scale system development. Relevant publications Toon, G. C., J.-F. Blavier, B. Sen, R. J. Salawitch, G. B. Osterman, J. Notholt, M. Rex, C. T. McElroy, and J. M. Russell III, Ground-based observations of Arctic ozone loss during spring and summer 1997, J. Geophys. Res., 104, 26,497-26,510, 1999 G. D. Sharp, P. Wang, S. Serati, T. Ewing, □Liquid Crystal Fourier Transform Spectrometer□, SPIE AeroSense, (1998).	

Proposal Number	ACT-02-0017
Title	Ultra-High Efficiency L-Band Transmit/Receive Modules for Large Aperture Scanning Antennas
PI	Edelstein, Wendy N,
Abstract	
Synthetic aperture radar (SAR) has proven to be a valuable technique for Earth topographic mapping, tectonic mapping, disaster management, quantifying the mass balance of both ice sheets and sea ice, measurement of vegetation and soil moisture, and understanding the dynamics of the coastal oceans. These measurements have been successfully demonstrated with NASA's Shuttle Imaging Radar missions, including SIR-C/X-SAR and SRTM, as well as with the earlier Seasat mission. The recently proposed ECHO ESSP mission will provide a measurement platform for global earthquake and natural hazard monitoring. To address NASA's requirement for global accessibility and fine temporal resolution, a geosynchronous SAR mission concept is currently being formulated under NASA's Global Earthquake Satellite study. SAR has demonstrated numerous benefits over other measurement techniques such as the ability to image day and night, under a variety of topographic, weather and land cover conditions. To provide global access along with fine temporal sampling, multiple spacecraft are required. The primary disadvantage of SAR is the high cost to implement and operate these missions. Mass and power consumption are primary factors contributing to the high mission costs. This proposal addresses the need for very high efficiency transmitter technologies by developing an ultra-high efficiency transmit/receive (T/R) module operating at L-band with overall efficiency exceeding 70%. The technology will have broad application to numerous L-band radar missions. It could also be scaled to other SAR frequencies for increased utility.	

Proposal Number	Award No: ACT-02-0005
Title	Development of a 1k x1k GaAs QWIP Far Infrared Detector Array
PI	Jhabvala, Murzy
Abstract	
The goal of this program is to catapult Gallium Arsenide (GaAs) Quantum Well Infrared Photodetector (QWIP) technology to the edge of the large format infrared (IR) technology industry. We intend to design, fabricate, hybridize and fully characterize a 1,024 x 1,024 (1K x 1K) GaAs QWIP detector array sensitive to the 8-14 micrometer infrared spectral region. The QWIP array will be fabricated utilizing Molecular Beam Epitaxial (MBE) growth processes that will be specifically band-gap engineered to yield the 8-14mm broad IR response. The pixel size will be 25mm x 25mm. The goal of this proposal not only represents a major leap in large format GaAs QWIP imaging array technology but will also, in this one leap, bring QWIP technology to the level of technology maturity currently available in Mercury Cadmium Telluride (MCT). Although each of these two technologies enjoy advantages (as well as disadvantages) with respect to each other, GaAs QWIPS have not been developed in formats larger than 512 x 640 and have remained relatively narrow band [1], typically on the order of 0.4-2mm in	

spectral response width. Comparable MCT arrays are available from only one source in the United States and the availability and performance of these arrays has been problematic. Additionally, they tend to be very costly and relatively difficult to manufacture (hence only one vendor). We intend to penetrate these barriers and pave the way for the development of very, very large format far IR QWIP arrays (>2Kx2K). Our team consists of members from the Instrument Systems and Technology Center of NASA□s Goddard Space Flight Center (GSFC), the Infrared Focal Plane Array Technology Group at the Jet Propulsion Laboratory (JPL) and the Infrared Materials and Devices Branch of the Army Research Laboratory (ARL). This team is also pioneering the development of hyperspectral IR imaging QWIP arrays [2]. Each group brings its own unique expertise to the project and previous collaborations have been successful, strong and mutually beneficial for all the team members bringing accolades to their representative organizations [3].

Proposal Number	ACT-02-0066
Title	Multiband Reconfigurable Synthetic Aperture Radar
PI	Knowles, Gareth,

Abstract

There is an ever-increasing demand for common aperture antenna system designs that are multiband, low-profile (i.e., conformal), lightweight, and low-cost. This is especially true of airborne and spaceborne antennas where multiband performance is required and where size and weight constraints are placed on the system design. There are currently no satisfactory design methodologies available that lead to antenna systems capable of meeting all these requirements simultaneously. The research proposed in this effort will focus on developing a new and innovative common aperture approach for designing thinned conformal multiband arrays that are lightweight as well as low-cost. The proposed technique is very flexible and, if successful, could be used to design multiband antenna arrays for a wide variety of applications, including those involving aircraft and spacecraft. The capability to completely internally reconfigure the same antenna moment by moment will for the first time enable the ability to introduce a complex antenna configuration at any fixed moment. This ability to control individual dielectric tunable antenna elements (which is completely new), combined with electronic phasing, would provide NASA with large single pass swath high-resolution synthetic aperture radar capability. This means that new SAR instruments will be capable of measuring new unique Earth parameters. The resulting instrument has low wiring requirements and could be implemented as either small SAR or large distributed SAR. The extensive facilities represented by CTFD, MRL and MRC combined with the capability for advanced electronics design and program management experience at QorTek provides precisely the necessary capabilities to realize this new instrument component technology.

Proposal Number	ACT-02-0045
Title	Quantum Gravity Gradiometer for Sub-Surface Mapping
PI	Maleki, Lute,

Abstract

We propose to advance the development of an ultra-sensitive gravity gradiometer with the potential for new capabilities to study the dynamics of solid and fluid Earth and to perform detailed sub-surface mapping from space. This measurement system is based on the utilization of atom-wave interferometry for the realization of a gradiometer which uses atoms as the proof mass. The capability realizable with this technique will open a new era for the study of various models of the solid and fluid Earth, and for the investigation of temporal changes and dynamic processes. We have already demonstrated the operation of an atom-interferometer as an accelerometer in the laboratory. A gravity gradiometer consists of two such atom-interferometers to measure the gravity acceleration difference over a given distance with high common-mode rejection for non-gravitational noises. The proposed task is to demonstrate the operation of a ground-based gravity gradiometer with the state-of-the-art sensitivity. To accomplish this, two atom-interferometer-based accelerometers will be designed and built together with all necessary supporting optics and electronics. A high-performance inertial reference frame platform will be constructed for system characterization and test. The task also includes new technology development for performance improvement and subsystem development toward a flyable prototype. Based on the results of this task a prototype space-borne and/or an airborne instrument will be developed with the desired features of long-term stability, high accuracy, robust packaging, and operability of period of several years. The proposed development in the next three years will bring the TRL from current TRL 3 to TRL 4-5.We propose to advance the development of an ultra-sensitive gravity gradiometer with the potential for new capabilities to study the dynamics of solid and fluid Earth and to perform detailed sub-surface mapping from space. This measurement

Proposal Number	ACT-02-0079
Title	Development of a Large Format Visible-NIR Blind Gallium Nitride UV Imager for Atmospheric Earth Science Applications

PI	Mott, David B,

Abstract

To meet programmatic objectives of the Earth Science Enterprise (ESE), the proposal team is requesting funds to develop a state-of-the-technology Visible-Near Infra-Red (VNIR) blind UV imager, based on a large format array (256x256 and greater) of p-i-n photodiodes, fabricated from wide bandgap IIIA-Nitride materials, in particular (Al,In)GaN alloys. For simplicity, all of the IIIA-Nitrides will be referred to generically as GaN. Compared to small bandgap materials, such as silicon, these semiconductors have long wavelength cut-offs that can be tailored to neatly divide the UV from the visible, reducing the need for visible light rejection. The benefits include low dark current and significantly improved radiation hardness at room temperature when compared to silicon charge-coupled devices (CCDs). The advantages of GaN based arrays become more compelling when compared to photomultiplier tube (PMT) and microchannel plate (MCP) based imagers since they are small, light, rugged and operate at low voltage. Recently [1], Goddard has demonstrated a prototype 256x256 30?m square element GaN array of photoconductive detectors, indium bump bonded to a silicon readout integrated circuit (ROIC) and illuminated through the sapphire substrate. The array showed high sensitivity to UV light from below 200 to 365 nm with a sharp reduction in response at longer wavelengths. Unfortunately, the photoconductor structure is not an ideal choice for many atmospheric earth science applications. However, using GaN structures that operate in the photovoltaic mode, large format photodiode arrays with cutoff wavelengths in the spectral range of interest 200 to 400nm can be fabricated. Recent advances in the growth of GaN hetroepitaxial films has enabled the fabrication of single element p-i-n photodiodes with high QE, low dark current and fill factors approaching 100%. Imagers based on these types of detectors can theoretically have a RMS noise of tens of electrons when coupled to state-of-the-art ROICs. The team believes that prototype 256x256 and 512x512 hybrid GaN p-i-n photodiode arrays exhibiting low dark current and high QE can be produced and fully integrated into UV imaging systems within three years, strategically positioning the proposed technology at TRL4/TRL5.

Proposal Number	ACT-02-0054
Title	T/R Membranes for Large Aperture Scanning Antennas
PI	Moussessian, Alina

Abstract

Using the current technology future SAR missions where very large arrays are required will not be possible. This is due to the heavy weight of the antenna and its inability to scan the beam. Lightweight, large-aperture, electronically-steerable space-based radar antennas are required to address the Earth Science Enterprise future science measurement needs. One method to dramatically reduce the weight, volume and associated cost of space-based radars is to replace the conventional rigid manifold antenna architecture with a flexible thin-film membrane. JPL has successfully demonstrated passive multi-layer-membrane patch-array antennas that provide an order of magnitude reduction in weight compared to conventional rigid antennas. To further reduce the cost and weight and provide 2D scanning required by space-based applications we will integrate the Transmit/Receive (T/R) function into the inflatable antenna elements. The major milestones of this work are (1) identifying a system architecture that integrates the inflatable structure and its RF microstrip patch elements with the membrane-compatible T/R electronics. This includes RF, digital and DC power distribution (2) packaging and attachment of a membrane compatible T/R module (3) implementation of a Local Thermal Management technology. We will demonstrate these integrated technologies in a representative unit cell. Through our current research in inflatable membrane antennas and T/R membranes we have done preliminary work in antenna architectures, technology selection for packaging, fiber attachment to antenna, and membrane support material. Relevant publications: [1] A. Moussessian, L. DiDomenico, W. Edelstein, ''Architectural Study of Active Membrane Antennas,'' submitted to ANTEM, Canada, July, 2002 [2] M. Celis, K.T. Lien, E. R. Brown, J. Huang, and W. Edelstein, Local Thermal Management for Space-Borne Inflatable RF Antennas, to be presented at the ITherm 2002 Conference, San Diego, CA. [3] Huang, Lou, and Caro, ''Super Low Mass Spaceborne SAR Array Concepts,'' presented at the IEEE Antennas and Propagation Symposium, Montreal, Canada, July 97.

Proposal Number	ACT-02-0040
Title	Lightweight, Deployable, Dual-Frequency/Polarization Microstrip Antenna Array for Remote Sensing of Precipitation
PI	Papapolymerou, Ioannis (John)

Abstract

It is the NASA Earth Science Enterprise□s (ESE) goal to develop a scientific understanding of the Earth□s environmental system and its response to natural and man-made changes, which will enable better prediction of climate, weather, and natural hazards. Of the forces acting on the climate, it is estimated that 40% are due to human actions and 60% are due to feedback effects on precipitation and temperature changes. Therefore, any attempt to understand the climate system must include accurate monitoring and measurement of the global precipitation, evaporation, and cycling of water. To monitor precipitation patterns, NASA requires dual-frequency,

dual-polarization radar and radiometers with identical radiation patterns for each frequency and polarization. More importantly, these systems must have low-cost, low-mass, deployable antennas with large surface area that can be rolled-up or folded for launch and then deployed in space, as well as low-power beam scanning and shaping electronic capabilities. In this project, we propose to develop a dual-frequency, dual-polarized antenna array on a flexible Liquid Crystal Polymer (LCP) organic substrate that has low-loss and small weight, as well as multi-layer and low-cost fabrication capability. Except for the length and number of elements the array would be identical to the one required by the NASA precipitation radar. The array will consist of two sets of microstrip patch antennas and associated feed networks in a multi-layer configuration. Coupling between the two sets of microstrip patches and the feed network will be reduced by implementing Electromagnetic Band Gap (EBG) structures. Furthermore, we propose to develop RF MEMS switches and phase shifters on LCP substrates that will be used to control the RF signal path and permit beam scanning at low-power requirements. At the completion of the program, the performance of the various components and the array will be established and they will be ready for space qualification testing. Since the proposed approach involves revolutionary and breakthrough concepts it represents a technology advance from TRL 2 to TRL 4.It is the NASA Earth Science Enterprise□s (ESE) goal to develop a scientific understanding of the Earth□s environmental system and its response to natural and man-made changes, which will enable better prediction of climate, weather, and na *[sic]*

Proposal Number	ACT-02-0138
Title	Development And Verification of Technology for an Earth Observing Deployed Lidar Telescope
PI	Peterson, Lee D

Abstract

The University of Colorado (CU) proposes, in collaboration with NASA Langley Research Center (LaRC) and The Boeing Company, to develop and bring to flight readiness essential component technology for the deployment of Earth observing lidar telescopes. Substantial investment by NASA in precision deployment research over the last ten years has lead to the potential for passively deploying a low mass, low cost, 2.5 meter class lidar telescope from a compact (Pegasus-class) launch volume. In particular, the material, mirror fabrication and part of the precision component mechanism technology has been developed and demonstrated to satisfactory performance. However, three essential elements of this technology remain at low technical readiness levels: - Precision latching of the deployed telescope to tolerances acceptable for lidar applications - Experimental verification of the deployment precision of a single telescope petal including the effects of gravity on the precision - Theoretical simulation of the single petal deployment precision and stability, so that system level on-orbit tolerances can be predicted and incorporated into designs The proposed research project will address each of these areas through the following activities: - Develop a new precision latch for the existing LaRC lidar petal test article that achieves the micron level deployment precision required of a lidar system - Experimentally measure the deployment repeatability and post deployment stability of the single petal test article in two gravity orientations (horizontal and vertical) - Develop and validate models of the mechanics of the petal test article that capture the effect of gravity on the deployment precision and post-deployed stability. Testing of the proposed deployment systems would pave the path to a space validation mission, reduce the cost, risk, and development time of future missions, and increase their accuracy and their safety margins.

Proposal Number	ACT-02-0050
Title	Low-Power Radio-Frequency Analog-to-Digital Converter (RF-ADC) for Digital Microwave Radiometry with Application to Soil Moisture Remote Sensing
PI	Piepmeier, Jeffrey

Abstract

We propose to develop a low-power radio-frequency analog-to-digital converter (RF-ADC) for digital microwave radiometry. The target application is synthetic thinned array radiometry (STAR) for 10-km soil moisture remote sensing. The RF-ADC, however, will be developed to be as broadly applicable as possible. Commercially available high-speed ADC□s are not optimized for microwave radiometry and typically dissipate too much power for STAR applications. The proposed RF-ADC will be designed using low-power SiGe IC technology and will be tailored to digital microwave radiometry. The RF-ADC will enable digital-RF microwave radiometer architectures, where RF signals are directly sampled rather than using a frequency downconversion stage. This technique can greatly reduce STAR system complexity by removing the need for mixers and local oscillator signal distribution. The RF-ADC will operate at 500 MSps with 1.5-GHz input bandwidth and have at least a 2-bit output. Target power dissipation is less than 330 mW.

Proposal Number	ACT-02-0034
Title	Advanced UV and Visible Ultra-Narrow Interference Filter Technology Development

PI	Potter, John

Abstract

Narrowband UV interference filters are crucial components of many remote sensing technologies ranging from ground-based to air-borne to space. Such filters are used to select signals in sun photometers, airborne lidars and space-based systems such as Hubble Space Telescope. Barr Associates is the industry leader in interfernce filter research and development, particularly in the UV region. Using new materials and process techniques, it is clear that a focussed two year project will result in substantial improvements in UV filter transmittance performance, while maintaining other important characteristics such as out-of-band rejection. Specifically, we propose a 30 month research activity consisting of: 1.) Research and development in narrowband interfernce filter technology, 2.) specification of several key filters in the UV and visible spectral ranges, 3.) Manufacturing of these filters at Barr Associates in consultation with NASA/Goddard SFC personnel 4.) Validation of these filters through ground-based experimentation at NASA/GSFC. We believe we can improve the transmittance by a factor of two while improving the signal-to-noise by an order of magnitude. This will enable future instruments to be constructed with equivalent or improved performance at lower cost and weight.

Proposal Number	ACT-02-0084
Title	Unified Onboard Processing and Spectrometry
PI	Tsay, Si-Chee

Abstract

Support is requested to unify onboard processing techniques with novel compact, low-power, low-cost spectrometers being developed at Goddard for eventual space missions. Increasingly, scientists see spectrometers as the wave of the future in passive Earth remote sensing. But, the vast volume of data generated by a spaceborne imaging spectrometer sampling in the spatial and spectral dimensions could easily require ten times the present EOSDIS capacity ☐ something NASA simply cannot afford. Right now, spectrometry is rushing far ahead of onboard processing. Our contention is that spectrometry and its onboard processing algorithms must rather advance in lockstep, and eventually unite in an indistinguishable fashion. Spectra must furthermore be onboard-processed to glean just what is new and not send to the ground what we already know. To this end, we propose a different strategy in which we use physical models to remove the known information in the spectra, and send just the losslessly-compressed remainder to the ground. The remainders are much more compressible than the original spectra. By archiving the models along with the compressed remainders, the original data can be reconstructed as needed. We estimate compression factors of 10 to 100 are possible using a combination of model-based removal followed by traditional compression. Specifically, we propose to: (1) adapt the best radiative transfer models for predicting spectra, and unite these with a lossless compression back end to produce algorithms appropri-ate for hard-coding into custom-manufactured ultra-low-power ASIC or FPGA chips, (2) implement and demonstrate these lossless data compression chips as onboard processing for Goddard☐s LAS (0.4-2.5 ?m, 1024x1024 detector array) and QWIP (3☐15 ?m, 512x640 detector array) spectrometer prototypes, (3) design and construct logic interfaces that incorporate these data compression chips for the LAS and QWIP spectrometers, and (4) conduct test flights to demonstrate the correct functioning of the new onboard processing technology. This is a potentially revolutionary instrument concept with wide appplicability for many space missions.

Proposal Number	ACT-02-0096
Title	Development of High Performance Laminated Electroformed Shape Memory Composite Materials for Lightweight and Deployable Optics
PI	Varlese, Steven J.

Abstract

Composite-metal laminated optics that have the potential to meet the requirements for ☐Ultra-lightweight, deployable concepts for large aperture optical systems☐ and ☐Compact, light weight, optical systems☐ as requested in NRA 02-OES-01. The intent of this proposed effort is to validate the feasibility of this ultra-lightweight mirror concept with the fabrication and test of a 0.5 meter diameter mirror. This effort will synthesize previous work done by Ball Aerospace in lightweight optics, by CTD in shape memory resins, and Northwestern University in metal film mirrors. The concept merges the lightweight and flexible properties of elastic memory composite membranes with the low scatter and figure accuracy of a thin, electroformed metal layer to provide a robust ultra-lightweight mirror system with the potential to meet the needs of NASA☐s near-term and far-term Earth Sciences missions. This innovative approach can enable a new class of lightweight, deployable, large-aperture telescopes for Earth observation or astronomical missions. The 30-month effort advances the technology from system-level feasibility based on the properties of existing optical quality electroforming and fiber reinforced shape memory resins to produce a 0.5 meter operational system for test in the laboratory. In the first year the team will perform a requirements analysis to set both system and individual material target performances. These requirements will then feed into the system design and modeling, and development of the key processes including fabrication and test of proof-of-concept optical components. The balance of the program will focus on the production of a 0.5-meter diameter test optic, which will be used for optical testing and a deployment demonstration. The goal is to demonstrate the feasibility of technology to meet the surface quality necessary for meter class, deployable, microwave to near-infrared and visible wavelength reflectors.

Proposal Number	ACT-02-0039
Title	Compact, Lightweight Dual-Frequency Microstrip Antenna Feed for Future Soil Moisture and Sea Surface Salinity Missions
PI	Yueh, Simon H.

Abstract

The objective of this research is to develop an innovative, compact, lightweight, dual-frequency antenna feed for future soil moisture and sea surface salinity (SSS) missions. Soil moisture and SSS are high priority measurements, identified in the Earth Science Enterprise (ESE) Strategic Plan, for addressing two ESE science questions: ''How does the Earth system respond to natural and human-induced changes?'' and ''How well can we predict future changes in the Earth system?'' A measurement system concept for spaceborne soil moisture and sea surface salinity missions was developed in an earlier Instrument Incubator study using a parabolic reflector antenna. Future high-resolution systems operating at low microwave frequencies (L-band) will require large reflectors with multiple feeds. These feeds must be compact and lightweight, with dual-frequency capability for passive and active sensing. A microstrip stacked-patch array (MSPA), intrinsically compact and lightweight, will be developed for use with large deployable reflector antennas. It will be a factor of 3 lighter, and a factor of 20 shorter, than the conical feedhorn design traditionally used to illuminate reflector antennas. The innovative feature is the stacked-patch design with two resonant frequencies at 1.26 and 1.41 GHz for L-band radar and radiometer operations. The proposed technology development will lower the mass, volume and cost of the antenna systems for future soil moisture and sea surface salinity missions. The reduction in volume and weight will also make the present mission concepts easier to accommodate on operational satellites. This technology development will be carried out with a step-by-step design and testing program. The first task is to obtain an optimal design for a single microstrip stacked patch to achieve desired resonant frequencies and minimum return loss. The second task will be to develop the MSPA. Performance tests will include return loss and antenna pattern measurements. The third task is to measure the insertion loss and stability of the MSPA with a cold sky radiometric calibration technique. This measurement will be performed using the previously developed Passive/Active L-/S-band (PALS) airborne microwave system. This development process is low risk and will be completed in 3 years.